

Evading Farm Support Reduction Via Efficient Input Use: The Case of Greek Cotton Growers

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Abstract

Utilizing a stochastic frontier approach, this paper examines the importance that input-oriented technical and scale efficiency may have for Greek cotton farmers in the context of the current EU cotton policy. To that end, a sample of cotton-growing farms in the representative cotton -producing county of Karditsa (central Greece) is empirically analyzed. The results suggest that the farms examined exhibit decreasing returns to scale and they are both scale and technically inefficient. Moreover, elimination of these inefficiencies could result in considerable gains; the cotton farmers examined could reduce production costs by 46.0%, by becoming both technically and scale efficient. Additionally, we estimate that if cotton farms in the area examined were technically and scale efficient the intervention price reductions (co-responsibility levy) imposed by the EU for excessive cotton production would be smaller for all Greek cotton growers.

1. Introduction

The measurement of technical efficiency of production units has become the focus of a rapidly expanding body of applied economic literature. Recently, this research has also been extended to the intimately related issue of scale efficiency, that is, the deviation of a firm's ray-productivity from the maximum attainable one. Naturally, the empirical measurement of technical and scale efficiency is an attractive research theme on its own, as a primary objective in production economics is the optimal resource utilization. However, there may be cases wherein achievement of technical and scale efficiency may also be advisable for additional reasons. One case may be policy regimes wherein financial support is offered only for a pre-determined output level. Productive units operating under such regimes may find that pursuing technical and scale efficiency may help them to not only utilize optimally their resources but also to preserve the support they enjoy under the policy regime.

Agricultural policies are a typical example of regulated regimes with provisions of maximum output levels for which farm support is available. Within the European Union (EU), provisions referring to "ceilings" of output produced (or area cultivated)

are included in many EU Regulations. As farm support (usually in the form of intervention prices) naturally functions as a signal to individual farmers to boost output, the actual way in which such ceilings are imposed becomes a crucial issue, both for farmers and policy makers in the EU member states. Greek cotton production has been an illustrative case. The current EU policy regime imposes a production quota at the country level, for cotton-producing member states. Exceeding this aggregate quota results in reductions of the intervention cotton price for all farmers. This mechanism however has failed to restrain Greek cotton production. Acting as price takers, individual producers conceived the demand for their produce as perfectly elastic and arranged their production only according to the EU intervention price, *not* the aggregate production quota. As a result, the Greek cotton production boomed the last twenty years despite the quota which in turn activated reductions in cotton intervention prices. This has been provoking loud protests by the Greek cotton growers the last five years about shrinking farm incomes.

The implementation of the EU cotton policy regime, on a more dis-aggregated basis (i.e., further allocating the country-level production quota down to the county or even to the farm level) could offer a natural settlement of this problem (Karagiannis and Pantzios, 2002). This paper offers an additional suggestion that could also help Greek farmers evade reductions in cotton intervention prices: the improvement of their technical and scale efficiency. In the past, high, EU-guaranteed cotton prices have influenced the scale of production in Greek cotton farms by encouraging farmers (i) to invest in modern equipment and expand production, (ii) use excessively water and chemical fertilizer and, (iii) divert even marginal productivity land to cotton farming. Under these circumstances, pursuing technical and scale efficiency may assist Greek cotton growers in two, complementary ways. First, it may yield substantial cost savings which could compensate for the reduced intervention prices caused by exceedingly high production levels. Second, (and more importantly) scale efficient production may result in lower output levels which in turn may mitigate or even eliminate reductions of the EU guaranteed cotton prices.

In this context, the objective of this paper is to estimate empirically technical and scale efficiency levels as well as their determining factors of Greek cotton farms. To that end, recent methodological developments stochastic frontier modeling which allow the measurement of technical as well as scale efficiency are utilized on a representative sample of Greek cotton farm operations from the county of Karditsa,

Thessaly. The empirical results are used to estimate average cost savings that could accrue to farmers if they were technically and scale efficient. Then, utilizing goal programming we attempt an estimation of the output (cotton) reduction that could have been achieved in the broader area of our survey if farms were operating under technical and scale efficiency. This finding is finally used to compute how much this lower production might have mitigated the guaranteed price reductions that cotton farmers have suffered in the period examined.

The rest of the paper is organized as follows. A brief overview of the Greek cotton sector is provided in the next section. Methodology and the theoretical model are developed in section 3. Section 4 discusses the data and the estimation results. Policy implications derivable from this study are offered in section 5. Section 6 concludes.

2. The Greek Cotton Sector

Traditionally, cotton growing has been a prominent farming activity in Greece providing the primary input to a major domestic processing industry (cotton ginners). During the last two decades the sector has shown an impressively rapid expansion. The acreage cultivated with cotton almost doubled during the 1980s reaching 240 thousand ha in 1991, from only 120 thousand ha in 1981 and kept expanding during the 1990s reaching 430 thousand ha in 1996. The volume of cotton production swelled according to the Greek Cotton Board from only 290 thousand tons in 1981 to about 1 million tons in 1996. Within the EU, Greece has thus become the largest cotton producer, accounting for about 70 percent of the total EU cotton production.

The sector's rapid enlargement has been mainly the result of past, high support-mechanisms of the EU cotton regime. Until 1986, the EU cotton policy was a typical deficiency payment scheme: the price received by cotton farmers was based on a target price (higher than the world price), predetermined annually by EU authorities. Faced with high financial costs however, the EU has replaced since 1987 this policy regime with an intervention mechanism consisting of: (i) an intervention price, (ii) an aggregate production quota, called *maximum quantity guaranteed* (MQG) which is set at the country-level and, (iii) a reduction in the intervention price, called *co-responsibility levy* which is applied to *all* cotton farmers when the actual cotton production of the country exceeded the pre-determined MQG.

As a result of the initial favorable CAP measures, cotton cultivation became gradually the primary farm activity (and source of income) for a growing number of agricultural households. Farmers diverted even marginal productivity land to cotton cultivation; invested in equipment (such as cotton harvesters, irrigation systems, and water drillings) and in general, they largely expanded their scale of operation. Naturally, negative environmental effects started to emerge as cotton ranks high in the list of heavily polluting crops; high levels of fertilizer residues have been measured in cotton fields and the excessive use of irrigation water appears to have reduced underground water supplies to alarming levels.

In the wake of the latest reform in the CAP cotton regime, production expansion is not anymore associated with corresponding increases in farm revenues. However, as the production quota was imposed at the country-level, individual cotton growers routinely ignored it and kept expanding their own production. Recently, cotton growers played a leading role in loud farmer protests against the EU-imposed cotton production quota claiming that it shrinks drastically their farm income in the face of ever increasing production costs.

3. Methodological Framework

Two measures of technical efficiency can be defined according to whether one adopts an output-expanding or an input-conserving approach (Kumbhakar and Lovell, 2000, pp. 46-48). The first one is the output-oriented *Debreu-type* measure, defined as the ratio of the observed to maximum feasible output, given the production technology and the observed input use. The second one is the input-oriented *Shephard-type* measure, defined as the ratio of minimum feasible to observed input use, given the production technology and the level of output.

Both measures of technical efficiency can be obtained from the econometric estimation of the stochastic production frontier (SPF) model suggested independently by Aigner *et al.* (1977) and Meeusen and Van der Broeck (1977). In this analytical framework the agricultural output is treated as a stochastic production process of the following general form:

$$y_i = f(x_i; \beta) \cdot \exp(\varepsilon_i) \quad \text{and} \quad \varepsilon_i \equiv v_i - u_i \quad (1)$$

where $f(\cdot)$ is approximated by a translog production function, *i.e.*,

$$\ln y_{it} = \beta_0 + \sum_{j=1}^n \beta_j \ln x_{jit} + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \beta_{jk} \ln x_{jit} \ln x_{kit} + \varepsilon_{it} \quad (2)$$

where y_i is the observed output produced by the i^{th} farm, x_{ji} is the quantity of the j^{th} input used by the i^{th} farm and, β is a vector of parameters to be estimated. The component v_i is a symmetric *iid* error term representing random variation in output due to random exogenous factors, measurement errors, omitted explanatory variables, and statistical noise. The component u_i is a non-negative error term representing the stochastic shortfall of the i^{th} farm's output from its production frontier due to the existence of output-oriented technical inefficiency.

Estimation of input-oriented technical efficiency is possible within the above model specification using the approach suggested by Atkinson and Cornwell (1994) and extended later on by Ray (1998) Reinhard *et al.* (1999). Specifically, all factors of production are multiplied by a scalar θ^0 such that the observed level of output is still feasible. Thus the model in (1), assuming that $u_i=0$, can be written as:

$$y_i = f(\theta_i^0 x_i; \beta) \cdot \exp(v_i) \quad (3)$$

Since under weak monotonicity output-oriented technical efficiency should imply - and must be implied by - input-oriented technical efficiency, we can set the input-oriented specification in (3) equal to the output oriented specification in (1). Then solving for θ_i^0 farm- and time-specific estimates of input-oriented technical efficiency (TE_i^I) can be obtained. These estimates directly indicate cost savings which are possible through the elimination of input-oriented technical inefficiency (Kopp, 1981, p. 490). Specifically, $1 - TE_i^I$ indicate the reduction in total cost if input-oriented technical inefficiency is eliminated.¹

Both measures of technical efficiency are shown in Figure 1. Let us assume that a farm i uses \bar{x} amount of input x to produce \bar{y} level of output (point A). Obviously the farm in question is technical inefficient as it does not operate on its production frontier given by $f(x)$. The output-oriented measure of this technical inefficiency is

defined as the ratio of the observed to the maximum attainable output (given at point D), that is $\bar{x}A/\bar{x}D$. Analogously, an input-oriented measure of technical inefficiency is given by the ratio of optimum over the actual input use, that is $O\bar{x}'/O\bar{x}$.

On the other hand, input-oriented scale efficiency can be estimated in the context of the SPF model following the approach suggested by Ray (1998). Specifically, in the context of the translog production frontier input-oriented scale inefficiency can be calculated from:

$$SE_i^I = \exp\left(\frac{\left(1 - \sqrt{E_i - 2Bu_i}\right)^2}{2B}\right) \quad (4)$$

where, E_i is the local measure of the returns to scale for the i^{th} farm, u_i is the output-oriented technical inefficiency of the i^{th} farm and, $B \equiv \sum_j \sum_k \beta_{jk}$ is the sum of the second-order parameters of the translog production frontier in (2). If the matrix $|\beta_{jk}|$ is negative definite, then $B < 0$.

If the farms in the sample exhibit decreasing returns to scale, which is probably the case of the Greek cotton sector, then making them scale efficient would result to a reduction in their total cotton produced. In order to compute that potential reduction in cotton produced and thus to approximate the reduction in the co-responsibility levy as well as the possible reduction in total cost of production we need to compute the input-output bundle that make the i^{th} farm scale efficient, from an input conservation perspective.

In terms of Figure 1 we need the combinations (\bar{x}', y_1) and (\tilde{x}, \tilde{y}) , respectively, where $\bar{x}' = \theta^0 \bar{x}$ and $\tilde{x} = \theta^* \bar{x}$. If all farms in the sample exhibit decreasing returns to scale then inputs must be scaled down in order to achieve the most productive scale size, (point C) where the ray average productivity of inputs is maximized. Otherwise inputs should be scaled up in order to attain maximum scale efficiency levels. If diminishing returns to scale prevail, then the input reduction for the i^{th} cotton farm to be scale efficient can be estimated from:

$$(\theta_i^0 - \theta_i^*) \bar{x}_i \quad (5)$$

Following Ray (1998, pp. 189-91), θ_i^0 (input-oriented technical efficiency) and θ^* can be estimated in the context of the translog specification as:

$$\theta_i^0 = \exp\left[\frac{-E_i + \sqrt{E_i^2 - 2Bu_i}}{B}\right] \text{ and } \theta_i^* = \exp\left[\frac{1 - E_i}{B}\right] \quad (6)$$

By computing the technically and scale efficient input levels \tilde{x} from equation (5) and inserting them into the fitted production frontier we can compute the corresponding output level \tilde{y} . Decreasing returns to scale at the actual point A imply that \tilde{y} is less than \bar{y} . Thereafter the potential output reduction and the corresponding cost savings when productive units become scale efficient can be obtained.

These output reductions are used to compute the potential increase in farm's total profits that would arise from the corresponding decline in the co-responsibility levy. For doing so we generalize the findings obtained from our sample survey to the whole county of Karditsa. In order to do that each individual farm in the sample has been weighted. These weight-coefficients are defined through goal programming in two stages. First, each sub region relative weight were determined, and then farms in each sub region were weighted accordingly to represent all other farms of the sub region.

The model is specified as follows: weight coefficients, one for each farm i was determined in such a way that deviations for regional crop mix were kept minimal. The difference between maximum and minimum value of the weight coefficients is a control variable to be minimized. The mathematical form of the goal programming model is as follows:

$$\begin{aligned} & \text{MIN } (\max\lambda - \min\lambda) \\ \text{s.t. } & \sum_k \sum_i \lambda_i s_{ik} + d_j^- - d_j^+ = s_j^R \quad \forall j \in J \\ & d_j^- \leq ps_j^R \quad \forall j \in J \\ & d_j^+ \leq ps_j^R \quad \forall j \in J \\ & \min \lambda \leq \lambda_i \quad \forall i \in N \\ & \lambda_i \leq \max \lambda \quad \forall i \in N \end{aligned}$$

where, $i \in N$ are the total farms in the sample, $j \in J$ is the crop group in the county (e.g. cereals), $k \in J$ is the individual crop within the crop group J , s_{ik} is the surface of crop k that belongs to the corresponding element j for farm i , s_j^R is the surface cultivated by crop group j in the county, p is the percentage of tolerated deviation from regional crop mix, λ_i is the weight coefficient for farm i and, d_j are the deviations from the crop group j .

First, we select the elements to be compared in the sample and the population. They can be crops, groups of crops (cereals etc), or other farm data such as irrigated land per total useful surface in the farm. Each of these elements corresponds to an additional constraint. There is a compensation possibility between the deviation tolerance and the difference between maximum and minimum weights. For instance, if we aim at a minimal deviation of 1% of the observations then the obtained results will differ significantly as it will be compelled to assign higher weights to some farms and to almost ignore others with a crop mix different of the regional crop mix.

4. Data and Estimation

Data

The data used in this paper come from a questionnaire survey of 172 cotton farms in the county of Karditsa which belongs to the region of Thessaly (central Greece) for the 1997-98 cropping year. Thessaly is one of the major agricultural regions of the country and historically it has been a prime area for cotton farming. Summary statistics of the key-variables of the surveyed farms appear in Table 1.

The variables involved in the analysis are measured as follows. In the production frontier equation (1) the dependent variable is the total annual cotton production measured in kilograms, while the independent variables include: (a) total labor, that is, hired and family (paid and unpaid) labor related to cotton production measured in hours; (b) farm land devoted to cotton cultivation measured in stremmas (one stremma equals 0.1 ha); (c) total amount of seeds used in cotton production measured in kilograms and; (d) total value of purchased inputs (fertilizers and pesticides) and capital (machinery etc) used in cotton cultivation, measured in euros (EUR).

In addition, we use a number of demographic and economic variables to explain the farm's technical and scale inefficiency. These include: (a) the age of the farmer

measured in years; (b) the value of the farm's total assets (comprising of the value of mechanical equipment, cultivated land and infrastructure) measured in EUR; (c) the formal education of the farmer measured in years of schooling; (d) the land fragmentation measured as the number of plots cultivated with cotton in each farm; and, (e) the "specialization" of the farm measured by means of a Herfindhall index (i.e., as the sum of the squared output shares of cotton and all other farm products produced on the farm).

Estimation results

The ML parameter estimates of the translog production frontier (1) are listed in Table 2. More than 2/3 of the estimated parameters in the production frontier and all the estimated parameters in the inefficiency model are found to be statistically significant at least at the 5% level. The relatively low value of the likelihood function is satisfactory for a cross-section data setting, indicating a good fit of the data. Moreover, the estimated production frontier satisfies all the regularity conditions, namely positive and diminishing marginal productivities, at the point of approximation. Specifically, monotonicity conditions are satisfied since all the marginal products are positive, while the determinants of the principal minors of the bordered Hessian matrix alternate their signs indicating diminishing marginal productivities. The estimated variance-ratio parameter, γ , is positive and statistically significant at the 1% level.²; its value implies that 84.35% of output variability is explained by the corresponding differences in output-oriented technical inefficiencies of the cotton farms examined.

Partial input elasticities with respect to output, and the returns to scale -RTS were computed for each farm in the sample. Their average value and descriptive statistics are reported in Table 3. Inspection of the table reveals that *ceteris paribus*, capital seems to have the largest impact on cotton production, followed by labor, acreage cultivated and seeds used. All farms in the sample exhibit decreasing RTS ranging from slightly below one to 0.784; the average RTS is found to be 0.878. Statistical testing confirms the existence of decreasing returns to scale at the 1% level of significance (the value of the respective LR-test is 46.23 with 5 degrees of freedom).

Technical and Scale Efficiency Scores

Input-oriented technical and scale efficiency scores of the farms examined (denoted as TE_i^I and SE_i^I , respectively) are listed in Table 4, in the form of a frequency distribution within a decile range. The table reveals that the cotton farms in the sample show considerable technical but only slight scale inefficiency. This implies that, primarily Greek cotton growers have not been successful in utilizing optimally their input use under the existing technology. More exactly, the computed input-oriented technical efficiency TE_i^I has an average value of 74.69% implying that the farms examined could have produced the observed cotton quantity using on the average, about 25% less input quantities within the current state of technology. Moreover, TE_i^I scores vary considerably across farms ranging from a minimum of 55.2% to a maximum of 94.6%. Of the 172 farms in the sample, only 65 (i.e., less than 40% of the farms examined) achieved input-oriented technical efficiency above 80%. This means that the majority of the sample participants face severe technical inefficiency problems.

Regarding scale efficiency, the average input-oriented scale efficiency SE^I is found to be 98.5%, ranging from 89.75% up to 99.99%. In fact, all but one of the farms in the sample have SE^I scores higher than 90%. This implies that the average ray productivity of the cotton farms examined would deviate from the maximum attainable one by about 1.5%, *if they operated under full technical efficiency* (Figure 1). Moreover, for individual farms in the sample the deviation of ray productivity from the maximum attainable one would range zero up to 10.25%.

Sources of Efficiency Differentials

To investigate the sources of input-oriented technical and scale efficiency of the farms examined we have regressed their TE^I and SE^I scores against a set of relevant demographic and economic variables using a two limit-Tobit model; the results are reported in Table 5. It must be noted that these parameter estimates are not subject to the same interpretation as conventional regression parameters; thus, we may only comment on the type of influence (positive or negative) they imply for the TE^I and SE^I scores.

A positive relationship is found between TE^f and the farmer's *age* (and therefore experience). This is in accordance with the notion that – besides education - hands-on experience obtained through years and learning-by-doing are critical factors in determining individual performance particularly in crop production³. However, the impact of age on the degree of technical efficiency needs not to be monotonically increasing: that is, young cotton producers may well be expected to become more efficient over time up to a point where the relationship between age and efficiency is leveled off; as they approach the retirement age efficiency declines. This notion of decreasing returns to human capital is captured by the negative relationship found between TE^f and the variable $(Age)^2$.

A positive relationship is also found between the farmer's *education* and the TE^f score of his farm. This lends support to Welch's (1970) hypothesis about the "worker effect", that is, the notion that education is a strong complement with most of the inputs utilized in the production process. Moreover, schooling may enhance the information acquisition process and the efficiency in the use of the acquired information.

On the other hand, *farm size* (measured as the value of farm's total assets) appears no to have any significant influence on TE^f scores. Lastly, TE^f is found to be negatively related to *farm specialization* (measured by means of a Herfindhal index). By construction, this index assumes higher values for farms specializing either in cotton or in crops other than cotton. Thus the finding implies that cotton farms which also diversify to other farming activities appear to be more technically efficient than highly specialized farms (either in cotton or in other crops). Regarding farms highly specializing in cotton, this finding may reflect the fact that for farmers relying almost exclusively on cotton, actual production volumes basically shape their farm income; thus they may tend to use inputs excessively in their effort to achieve as large produce as possible. With respect to farms highly specializing in other crops, this finding may be viewed as reflecting the massive entrance of farmers into cotton cultivation in recent years to take advantage of high support prices: producers lacking experience and skills in cotton farming and employing marginal productivity land have simply added cotton growing to their activities. It is clear that such marginal cotton growers cannot be as technically efficient as their colleagues who include cotton production among their major farming activities.

The same factors appear to have analogous relationships with the scale efficiency scores of the farms examined. More exactly, the farmer's *age* and $(age)^2$ have the same types of relationship with SE^I scores (as they have with TE^I scores) and they may be given similar interpretations. The same holds true for the farmer's *education*. Finally, *Total assets* and *specialization* do not seem to affect significantly SE^I scores.

Potential cost savings and co responsibility levy reductions

The average TE^I score of 74.7%% implies that (on the average) the observed cotton output levels could have been produced with 25.3% less production costs without altering production technology. Table 6 reports the potential cost reductions from eliminating input-oriented technical and scale inefficiency from the cotton farms examined⁴. Our calculations indicate that these cotton farms would be able to reduce their actual costs by 46% if they became technically and scale efficient. In particular, the farms examined would reduce their cost by 25.3% if they became technically efficient and by another 20.7% if, in addition, they became scale efficient. In absolute terms, these potential cost savings would be on the average, EUR 117/stremma. Reducing therefore technical inefficiency could substantially improve the economic viability of cotton farms. Conclusions on the level of cotton production can be made when farms become technically and scale efficient; in order to project to the county level reduced cotton production level by farm an idea of the representative power of each sample farm is necessary. For this purpose the goal programming method presented in section 3 has been used

The survey included 172 farms that belong to 20 communes in Karditsa plain. First these communes have been selected to represent plain and semi-mountainous areas of the region out of 83 communes in total that are classified to six homogeneous sub regions according to farm characteristics such as average size of farms, labor force available, irrigated land percentage and crop mix. Then a number of farms has been selected randomly from within each sub-region. Finally 172 farms have been surveyed that represent a total farm number about 16260 situated in the plain and semi-mountain communes of Karditsa, that is each sample farm represents about 100 farms. As policy recommendations will be extracted from the analysis and extrapolations would be made attempting to generalize conclusions, the necessity of a finer weighing of sample farms became apparent. For this purpose goal programming is used so that results can

be projected to the regional level with the minimal deviations from observed crop mix aggregates.

Utilizing goal programming we were able to determine weights for each sample farm. In average each sample farm represents 70 real farms of the county, some of them represent 500 (maximum weights) while others only 10 (minimum). The detailed picture of the weights per farm is presented in Figure 3.

Our calculations indicate that in the period 1997-98, cotton output would be reduced by 55,422.705 metric tons (MT) in the county of Karditsa, if all its cotton producing farms were both technically and scale efficient. The potential reduction of the co-responsibility levy (faced by all Greek cotton growers) is computed in Table 7. In 1997-98, actual cotton production in Greece was 1,045,488 MT; the country's production quota (MQG) was set at 782,000 MT; the target price was 331.7 drachmas/kg; and, the co-responsibility levy was 49.8 drachmas/kg (Karagiannis and Pantzios, 2002). In percentage terms, this co-responsibility levy represents a 15.01% reduction of the target price.

The actual Greek production exceed the pre-determined MQG by 38.8% in 1997-98; it would have exceeded the MQG by 31.72%, if the Karditsa county cotton growers were technically and scale efficient. Since the actual exceeding of the MQG by 38.8% resulted in 15% drop of the intervention price, simple algebraic calculations suggest that if the Karditsa county cotton growers were technically and scale efficient, the reduction of the intervention price (the co-responsibility levy) would have been 40.67 drachmas/kg in the period 1997/98. In other words, if *only* the Karditsa cotton growers were both technically and scale efficient, the financial penalty (i.e., the co-responsibility levy) for *all* Greek cotton growers would have been smaller by 9.1 drachmas/kg.

5. Policy implications

Our analysis indicates that the benefits the Common Agricultural Policy offered to Greek cotton producers have come at a rather heavy opportunity-cost. Specifically, the satisfactory farm income that the EU cotton regime secured in the past to cotton growers (via administrative prices, set well above world levels) allowed them to disregard efficiency considerations in the way they apply their production technology. Nowadays however, the resulting efficiency distortion is becoming a critical factor for Greek (and other EU) cotton growers, for at least two reasons. First, the EU itself has

taken a course of gradual reduction of its expensive farm programs; thus, ways to achieve cost savings are becoming increasingly important for the economic viability of farming operations. Second, further liberalization of the world agricultural markets will only intensify competition, thus making efficiency a major determinant for the survival of cotton producing countries.

The considerable technical and scale inefficiency in Greek cotton farming becomes also important in the light of the attitude Greek cotton farmers have been taking against the CAP cotton regime: as already mentioned, they have repeatedly protested claiming that their revenues are severely reduced by the current EU regime (outlined in section 2). This study indicates however that instead of blindly demanding higher prices to secure their income, cotton farmers could achieve a similar result via cost savings stemming from the reduction of their technical and scale inefficiency.⁵

Thus, the primary policy suggestion derivable from our study calls for Greek policy planners to complement the current EU cotton regime with structural policies which explicitly induce cotton farmers to improve the technical and scale efficiency of their operations. Such measures can effectively address the difficulties associated with the prospects facing Greek cotton growers, outlined above. First, they can implicitly induce Greek cotton farmers not to exceed (or at least exceed by less) the EU – imposed, cotton production quota (MQG), thus maintaining the level of EU support, currently available to them, and their farm revenue. Second, (and perhaps, more importantly) such measures may prepare Greek cotton growers to cope with future support reductions in light of future CAP reforms and increasingly integrated, world agricultural markets.

Specific measures of such complementary structural policies may include: (i) measures to improve the ability of cotton farmers to apply efficiently the existing technology e.g., measures designed to improve education, information acquisition, and learning-by-doing processes, (ii) incentives to farmers to adjust the excessive scale of their cotton operations; and, (iii) measures to favor “balanced” cotton farming operations by discouraging occasional or marginal cotton growers but also farmers which base their farm income exclusively on cotton production.

6. Concluding Remarks

Productive units operating with decreasing returns to scale under policy regimes wherein financial support is offered only for a pre-determined output level may find

that pursuing technical and scale efficiency is a deceive factor for the support level they enjoy. The Greek cotton production under the EU cotton regime is an illustrative case. This paper examines the importance that input-oriented technical and scale efficiency may have for the support Greek cotton farmers receive, in the context of the current EU cotton policy. For this purpose we estimated econometrically the technical and scale efficiency levels of a sample of cotton growers in the representative, cotton-producing county of Karditsa, in Thessaly-central Greece, for the period 1997/98. In addition, by utilizing goal programming we computed the cotton output of Karditsa county, if all cotton farming operations in the county were both technically and scale efficient.

Our empirical findings suggest that, in general, the cotton farms examined are technically and scale inefficient. The 1980s high support policies of the EU appear to have considerably contributed to the inefficiencies observed. Our analysis indicates that elimination of these inefficiencies could result in considerable gains; the cotton farmers examined could reduce production costs by 46.0%, by becoming both technically and scale efficient. Additionally, we estimate that if cotton farms in the area examined were technically and scale efficient the intervention price reductions (co-responsibility levy) imposed by the EU for excessive cotton production would be smaller for all Greek cotton growers. Policy recommendations derivable from our study suggest that Greek policy planners should complement the current EU cotton regime with structural policies which explicitly induce cotton farmers to improve the technical and scale efficiency of their operations. Such measures can effectively mitigate the amount by which Greek cotton farmers exceed the EU –imposed, cotton production quota (MQG), thus maintaining the level of EU support, currently available to them, and their farm revenue. Second, (and perhaps, more importantly) such measures may prepare Greek cotton growers to cope with future support reductions in light of future CAP reforms and increasingly integrated, world agricultural markets.

References

- Aigner, D.J., Lovell, C.A.K. and P. Schmidt (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6, 21-37.
- Atkinson, S.E. and C. Cornwell (1994). Estimation of output and input technical efficiency using a flexible functional form and panel data. *International Economic Review* 35, 245-255.
- Färe, R. and C.A.K. Lovell (1978). Measuring the technical efficiency of production. *Journal of Economic Theory* 19, 150-162.
- Greene, W.H. (1999). Frontier production functions in *Handbook of applied econometrics, Volume II: Microeconomics*, M.H. Pesaran and P. Schmidt (eds), Oxford: Blackwell Publishers.
- Karagiannis G., and C. J. Pantzios (2002). To comply or not to comply with policy regulations-the case of Greek cotton growers: A Note. *Journal of Agricultural Economics* 53, 345-351.
- Kopp, R.J. (1981). The measurement of productive efficiency: A reconsideration. *Quarterly Journal of Economics* 96, 477-503.
- Kumbhakar S.C. and C.A.K. Lovell (2000). *Stochastic Frontier Analysis*, Cambridge University Press.
- Meeusen, W. and J. Van der Broeck (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review* 18, 435-44.
- Ray, S.C. (1998). Measuring scale efficiency from a translog production function. *Journal of Productivity Analysis* 11, 183-194.
- Reinhard, S., Lovell, C.A.K. and G.J. Thijssen (1999). Econometric estimation of technical and environmental efficiency: An application to Dutch dairy farms. *American Journal of Agricultural Economics* 81, 44-60.
- Weersink, A., Turvey, C.G. and A. Godah (1990). Decomposition measures of technical efficiency for Ontario dairy farms. *Canadian Journal of Agricultural Economics* 38, 439-56.
- Welch, F. (1970). Education in production. *Journal of Political Economy* 8, 35-59.

Table 1
Summary Statistics of the Variables

Variable	Mean	StDev	Min	Max
Output (kgs)	22,736	17,139	2,000	94,500
Labor (hours)	1,728	1,587	131	8,574
Capital (EUR)	3,655	1,232	675	12,354
Seeds (kgs)	551	142	101	1,698
Land (stremmas)	83	45	15	260
Specialization (%)	90.9	14.2	42.3	100
Age (years)	53	7	37	70
Education (years)	8	0.39	7	10
Total Assets (EUR)	6,046	1,670	2,036	26,824

Table 2
Parameter Estimates of the Translog Stochastic Production Frontier for Greek Cotton Farms

Parameter	Estimate	Std Error
Constant	-0.1378	(0.0612)**
Labour	0.2833	(0.1039)*
Capital	0.2862	(0.1244)**
Seeds	0.1616	(0.0545)*
Area	0.1544	(0.0454)*
Labor x Capital	-0.0506	(0.0930)
Labor x Seeds	0.2333	(0.0920)**
Labor x Area	-0.2103	(0.0883)**
Labor x Labor	0.0591	(0.0266)**
Capital x Seeds	-0.4328	(0.1608)*
Capital x Area	0.1245	(0.1448)
Capital x Capital	0.1984	(0.0526)*
Seeds x Area	0.1889	(0.0912)**
Seeds x Seeds	-0.0828	(0.1268)
Area x Area	0.0926	(0.1211)
σ^2	0.1993	(0.0354)*
γ	0.9369	(0.0502)*
$Ln(\theta)$	-16.516	

*(**) indicate significance at the 1 (5)% level.

Table 3
Production Elasticities and Returns to Scale of Greek Cotton Farms

	Mean	StDev	Min	Max
Labor	0.2777	0.0512	0.1270	0.4332
Capital	0.2992	0.0813	0.0063	0.5533
Seeds	0.1300	0.1009	0.0171	0.4169
Area	0.1715	0.0791	0.0319	0.4351
RTS	0.8784	0.0386	0.7846	0.9716

Table 4
Frequency Distribution of Input-Oriented Technical and Scale Efficiency

Efficiency (%)	TE_i^I	SE_i^I
<20	0	0
20-30	0	0
30-40	0	0
40-50	0	0
50-60	16	0
60-70	51	0
70-80	40	0
80-90	51	1
>90	14	171
N	172	172
Mean	74.69	98.56
Minimum	52.21	89.75
Maximum	94.62	99.99

Table 5
Tobit Regression of Input-Oriented Technical and Scale Efficiencies on Specific Farm Characteristics

Variable	<u>Technical Efficiency</u>		<u>Scale Efficiency</u>	
	Estimate	Std Error	Estimate	Std Error
Farmers' Age (years)	1.0285	(0.4125)*	4.0125	(0.3145)*
Farmers' Age-squared (years)	-0.1023	(0.0044)*	-0.0502	(0.0017)*
Total Assets (€)	0.0011	(0.0014)	-0.0012	(0.0015)
Farmers' Education (years)	0.3458	(0.0125)*	0.8145	(0.1458)*
Specialization (Herfindhal index)	-0.9472	(0.2036)*	-0.3254	(0.3025)
McFadden R ²	0.4125		0.4025	

Table 6
Potential Cost Savings for Cotton Farms

	In Euros	In Euros/Stremma
Actual Cost of Production	14,163	237
Total Cost Savings	6,542	117
		(46.0)
Due to Elimination of:		
Technical Inefficiency	3,563	62
		(25.3)
Scale Inefficiency	2,979	55
		(20.7)

One stremma equals 0.1 ha. Numbers in parentheses are the corresponding percentage values.

Table 7
Potential Co-Responsibility Levy Reduction for *all* Greek Cotton Growers.

Period: 1997-98	Actual data	Estimates if Karditsa cotton growers were tech. and scale efficient
Actual cotton production	1,085,488 MT	1,030,065.295 MT (-5.1%)
Production quota (MQG)	782,000 MT	782,000 MT
Co-responsibility levy	49.8 drs/kg	40.67 drs/kg (-18.27%)

Figure 1
Measurement of Technical and Scale Efficiency

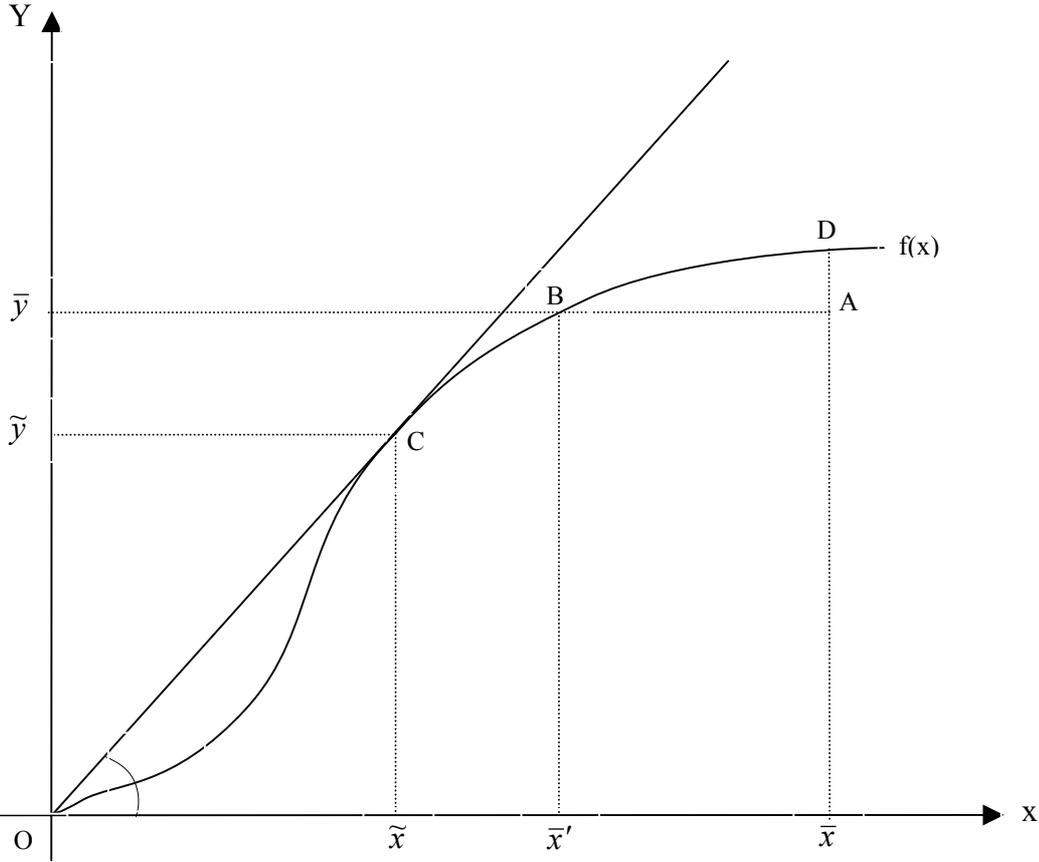


Figure 2
Municipalities in the Survey

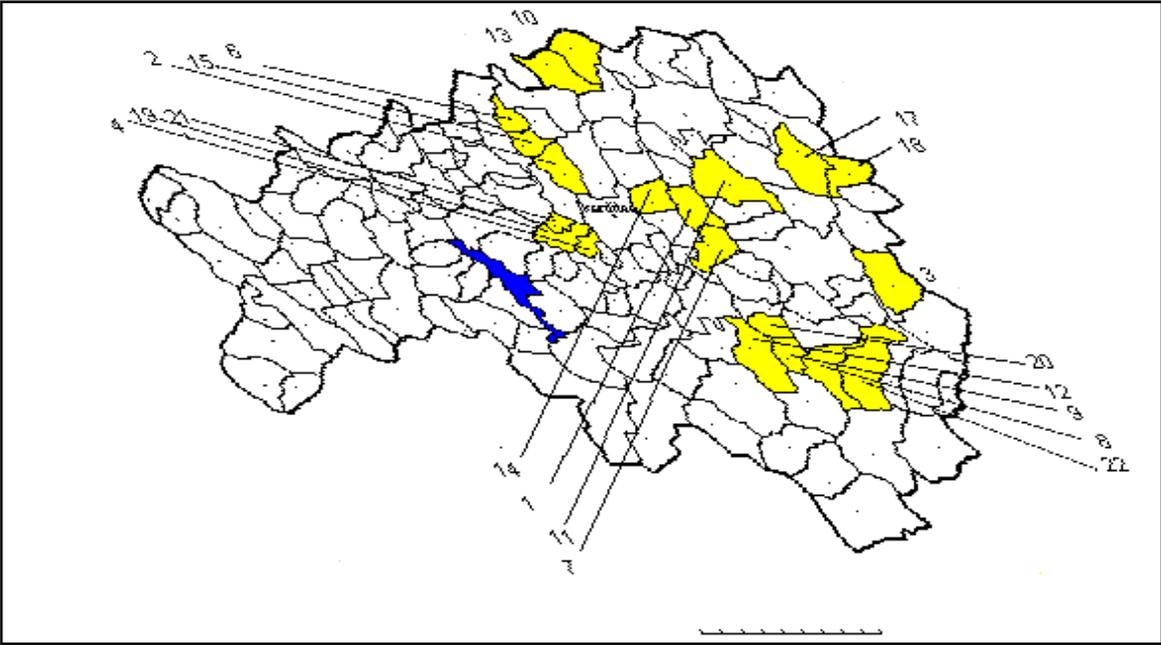
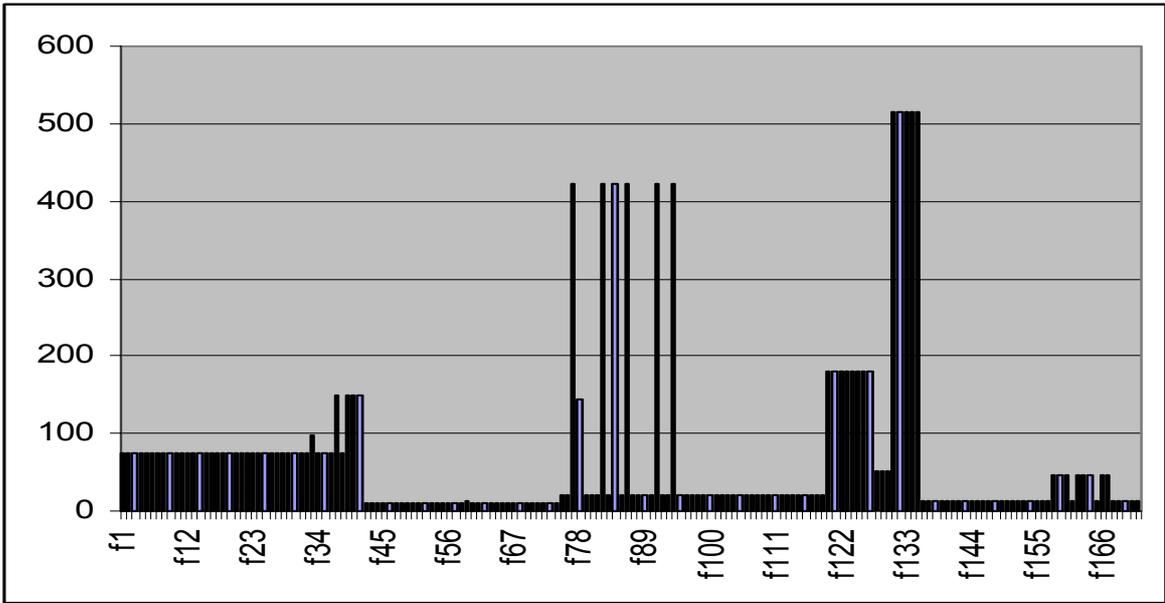


Figure 3
Farm Weight Distribution for the 172 Sample Farms



Endnotes

- ¹ This relationship between input-oriented technical efficiency and total cost of production is not valid for output-oriented technical efficiency measures except in cases where linear homogeneity (constant returns to scale) in all inputs holds (Färe and Lovell, 1978).
- ² It should be noted here that γ is not equal to the ratio of the variance of the technical inefficiency effects to the residual variance. This is because the variance of u is equal to $[(\pi - 2)/\pi]\sigma_u^2$ not σ_u^2 . The relative contribution of the inefficiency effects to the total variance term is equal to $\gamma^* = \gamma / \{\gamma + [(1 - \gamma)\pi]/(\pi - 2)\}$ (Greene, 1999, p. 101).
- ³ However, Weersink *et al.*, (1990) argued that inexperienced farmers tend to acquire more easily knowledge about recent technological advances than their older counterparts.
- ⁴ These estimates are obtained by multiplying total average cost by $(1 - TE_i')$.
- ⁵ In a different analytical framework Karagiannis and Pantzios (2002) show that full compliance with (rather than consistent violation of) the country-level production quota imposed by the current EU cotton regime would make Greek cotton farmers better-off. The empirical results of the present study lend additional support to the view that Greek cotton farmers can maintain their farm income by fully abiding to production controls and reducing production costs via efficiency improvements rather than persistently demanding ever higher, administrative prices.